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# Basal Area Growth of Arizona Mixed Conifer Species

Robert S. Embry and Gerald J. Gottfried[1]

*Growth data were collected from four small mixed conifer watersheds totaling 1,800 acres in east-central Arizona. Annual gross basal area increment was estimated to be 4.027 square feet per acre. This represents a 2.3 percent annual increase.*
KEY WORDS: Stand increment estimates, basal area measurement, mixed conifer forests.

Mixed conifer stands occupy about 6 percent of the commercial forest land in Arizona. The areas they occupy, however, are some of the most productive lands in the State. These mixed conifer forests are mostly uncut, all-aged stands of Engelmann spruce (Picea engelmannii), blue spruce (Picea pungens), Douglas-fir (Pseudotsuga menziesii), white fir (Abies concolor), corkbark fir (Abies lasiocarpa var. arizonica),[2] ponderosa pine (Pinus ponderosa), southwestern white pine (Pinus strobiformis), and quaking aspen (Populus tremuloides) in a wide variety of mixtures.

Large-scale harvesting of these mixed stands began in 1966. Optimum management practices have not yet been fully established. Growth information needed to prescribe satisfactory timber and watershed management practices is not available for these mixed species.

This Note presents data that will provide a means of estimating gross basal area and volume growth in mixed conifer stands.

[1]*Embry is Associate Silviculturist, located at Flagstaff in cooperation with Northern Arizona University; Gottfried is Associate Hydrologist, located at Tempe in cooperation with Arizona State University. Station's central headquarters is maintained at Fort Collins in cooperation with Colorado State University.*

[2]*On the Kaibab Plateau, corkbark fir is replaced by subalpine fir (Abies lasiocarpa var. lasiocarpa (Hook.) Nutt.).*



## Procedures

Growth data were obtained during an overstory inventory of about 1,800 acres of virgin mixed conifer forests on the four Willow-Thomas Creek watersheds on the Apache National Forest in east-central Arizona. This inventory was made according to methods developed by Ffolliott and Worley.[3] Increment borings were taken from one tree out of every four selected with a 25 BAF angle gage for diameter measurement. Growth information was collected from 991 trees on 556 sample points. Average annual gross basal area increment (BAI) for each d.b.h. class was computed from the increment core measurements. The distribution of sample trees by species is shown below:

| Species | Number of trees |
|---|---|
| Douglas-fir | 277 |
| Ponderosa pine | 172 |
| White fir | 155 |
| Quaking aspen | 121 |
| Engelmann spruce | 118 |
| Southwestern white pine | 100 |
| Blue spruce | 24 |
| Corkbark fir | 24 |
| Total | 991 |

[3]*Ffolliott, Peter F., and David P. Worley. An inventory system for multiple use evaluations. U. S. Forest Serv. Res. Pap. RM-17, 15 p. 1965. Rocky Mt. Forest and Range Exp. Sta., Ft. Collins, Colo.*

A basal area stand table was constructed from the basic inventory data by conventional point-sampling techniques (table 1).

## Results

**Basal area increment.**—The sapling-small pole size class accounts for almost half the total gross BAI of 4.027 square feet per acre per year (table 2). One-third of the total is produced by Douglas-fir.

The large standard errors associated with the sapling-small pole class are the result of converting basal area per acre to number of trees per acre in the double-sampling procedure to compute BAI. The smaller the diameter, the larger the number of trees it represents on a per-acre basis.

**Basal area growth percentage.**—The total gross annual BAI of 4.027 square feet per acre represents a 2.3 percent annual increase. The sapling-small pole class shows the greatest class increase with 6.7 percent (table 3). Corkbark fir has the greatest species increase, with 3.7 percent.

## Application of Results

The prediction of growth is necessary for the formulation of any management plan. Growth percentage provides a quick, simple, and relatively accurate method of predicting growth.

Volume growth is a function of basal area and height increment plus any changes in form. Volume growth may be a function of basal area increment alone in mature trees, in which height and form change very slowly. Such a condition would be restricted to the larger size classes in the mixed conifers.

If a short prediction period of 5 to 10 years is used and a precise estimate is not required, the growth percentages in table 3 may be used for all size classes. The volume in each species-size class multiplied by the respective growth percentage gives a useful and quick estimate of gross annual volume growth. At present we have total cubic-foot volume tables only for ponderosa pine. When such information becomes available for the other species, these growth percentages may be used.

The growth percentage method must be used with caution. Davis [4] states that ". . . the main difficulty with growth percent as a management tool is that it is not a quantity, but a relationship with all the shifty characteristics of percentages in general." Growth percentages vary by species, diameter class, and prediction period and are not constant for any stand, especially a natural, mixed stand.

[4] *Davis, K. P. American Forest Management. p. 98. N. Y.: McGraw-Hill Book Co., Inc. 1954.*

Table 1.--Basal area per acre on an 1,800-acre mixed conifer stand in east-central Arizona

| Size class | Douglas-fir | Quaking aspen | White fir | Ponderosa pine | Engelmann spruce | White pine | Corkbark fir | Blue spruce | Total | Distribution |
|---|---|---|---|---|---|---|---|---|---|---|
| | Square feet | | | | | | | | | Percent |
| Sapling-small poles (0.1-6.9 inches) | 8.45 | 6.92 | 3.55 | 2.43 | 3.51 | 1.57 | 1.03 | 0.45 | 27.91 | 16 |
| Poles (7.0-10.9 inches) | 6.56 | 12.41 | 2.74 | 1.26 | 5.44 | 1.71 | 1.89 | .63 | 32.64 | 18 |
| Small sawtimber (11.0-16.9 inches) | 11.38 | 7.15 | 3.69 | 3.87 | 9.22 | 2.43 | 2.16 | 1.03 | 40.93 | 23 |
| Medium sawtimber (17.0-22.9 inches) | 10.39 | 1.66 | 4.50 | 7.15 | 4.41 | 1.80 | .63 | .76 | 31.30 | 18 |
| Large sawtimber (23.0 inches plus) | 18.97 | .04 | 11.38 | 10.30 | 1.44 | 2.43 | .22 | .18 | 44.96 | 25 |
| Total | 55.75 | 28.18 | 25.86 | 25.01 | 24.02 | 9.94 | 5.93 | 3.05 | 177.74 | |
| | Percent | | | | | | | | | |
| Distribution | 31 | 16 | 14 | 14 | 14 | 6 | 3 | 2 | | |

Table 2.--Gross annual basal area increment per acre on an 1,800-acre mixed conifer stand in east-central Arizona (Confidence intervals are at the 95 percent level)

| Size class | Douglas-fir | Quaking aspen | White fir | Ponderosa pine | Engelmann spruce | White pine | Corkbark fir | Blue spruce | Total | Distribution |
|---|---|---|---|---|---|---|---|---|---|---|
| | Square feet | | | | | | | | | Percent |
| Sapling-small poles (0.1-6.9 inches) | 0.687±.214 | 0.262±.077 | 0.203±.084 | 0.188±.146 | 0.266±.140 | 0.105 | 0.125 | 0.043 | 1.879 | 47 |
| Poles (7.0-10.9 inches) | .147±.041 | .340±.095 | .061±.023 | .027±.012 | .133±.045 | .061±.024 | .047±.031 | .016 | .832 | 21 |
| Small sawtimber (11.0-16.9 inches) | .193±.038 | .126±.035 | .053±.023 | .060±.021 | .185±.046 | .035±.013 | .040±.020 | .016±.011 | .708 | 17 |
| Medium sawtimber (17.0-22.9 inches) | .094±.021 | .019 | .049±.014 | .066±.017 | .054±.017 | .020±.006 | .006 | .009±.006 | .317 | 8 |
| Large sawtimber (23.0 inches plus) | .120±.018 | <.001 | .080±.017 | .059±.011 | .012±.006 | .015±.006 | .001 | .004 | .291 | 7 |
| Total | 1.241 | .747 | .446 | .400 | .650 | .236 | .219 | .088 | 4.027 | |
| | Percent | | | | | | | | | |
| Distribution | 31 | 19 | 11 | 10 | 16 | 6 | 5 | 2 | | |

Blocked-in values are means of four or fewer sample trees expanded to a per-acre value. Intervals could not be calculated because of insufficient data.

Table 3.--Annual gross basal area growth percentage for mixed conifers in 1,800-acre stand in east-central Arizona

| Size class | Douglas-fir | Quaking aspen | White fir | Ponderosa pine | Engelmann spruce | White pine | Corkbark fir | Blue spruce | Average[1] |
|---|---|---|---|---|---|---|---|---|---|
| | Percent | | | | | | | | |
| Sapling-small poles (0.1-6.9 inches) | 8.1 | 3.8 | 5.7 | 7.8 | 7.6 | 6.7 | 12.1 | 9.4 | 6.7 |
| Poles (7.0-10.9 inches) | 2.2 | 2.7 | 2.2 | 2.1 | 2.4 | 3.6 | 2.5 | 2.6 | 2.5 |
| Small sawtimber (11.0-16.9 inches) | 1.7 | 1.8 | 1.4 | 1.5 | 2.0 | 1.4 | 1.8 | 1.6 | 1.7 |
| Medium sawtimber (17.0-22.9 inches) | .9 | 1.1 | 1.1 | .9 | 1.2 | 1.1 | 1.0 | 1.2 | 1.0 |
| Large sawtimber (23.0 inches plus) | .6 | 1.0 | .7 | .6 | .8 | .6 | .6 | 2.0 | .6 |
| Average[1] | 2.2 | 2.6 | 1.7 | 1.6 | 2.7 | 2.4 | 3.7 | 2.9 | [1]2.3 |

[1]Averages are derived from tables 1 and 2; i.e., $\frac{4.027 \text{ (table 2)}}{177.74 \text{ (table 1)}}$ = 2.3 percent.